

# FREQUENCY OF COLD-WET CLIMATIC CONDITIONS IN THE UNITED STATES<sup>1</sup>

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[Manuscript received Nov. 26, 1956; revised March 6, 1957]

## ABSTRACT

Cold-wet conditions occur most frequently in the extreme Pacific Northwest, with a second maximum in the Northeast from the Great Lakes to northern New England. The minimum occurrence is in the southern portions of Arizona and adjacent California, New Mexico, Texas, and Florida. During the colder part of the year (from October through April), cold-wet conditions occur over 50 percent of the time in the two above-mentioned regions of maximum incidence, reaching 70 to 80 percent in January.

In summer (July and August), cold-wet conditions occur less than 10 percent of the time except in the far northeastern and Lake States and on the north Pacific coast. The Olympic Peninsula of Washington has more than 30 percent frequency all summer, the highest in the country during this season.

## 1. INTRODUCTION

One of the most disagreeable types of weather is a combination of coldness and wetness. Such a combination calls for the development and use of special clothing and footwear to keep the body warm and dry, not only for comfort but for protection against lowered resistance associated with chill and against ever-present danger of trench foot. The problem is of universal concern, but is particularly serious for people spending much time in the open, such as farmers, loggers, police, and soldiers.

In view of the human significance of cold-wet conditions, to say nothing of their importance as a widespread and distinctive type of environment, it is desirable to inquire into the frequency with which they occur in different areas. Many previous authors, such as Köppen [1], de Martonne [2], and Thornthwaite [3], have developed climatic indices based upon combinations of temperature and rainfall, but these indices have dealt chiefly with monthly mean values, primarily for agricultural, ecologic, or geographic purposes. The cold-wet that affects an individual is not a mean, but a simultaneous occurrence of coldness and wetness at a given instant. Furthermore, precipitation is only one aspect of wetness; muddy ground, puddles, and slush represent another aspect. Similarly, low air temperature is only one factor contributing to coolness; wind and lack of sunshine are others.

The analysis of the natural frequency of occurrence of simultaneous combinations constituting cold-wet conditions has apparently not been attempted heretofore, and has in fact become feasible only because of the possibility of machine-analysis of masses of hourly data.

## 2. DEFINITION OF COLD-WET

A thoroughly miserable cold-wet type of weather would include temperature hovering just above freezing, falling rain driven by a penetrating wind, and muddy, slushy ground. To decide exactly what quantitative combinations and limits should be included in the concept of cold-wet, and to translate these values into quantities that can be processed with existing punch-card data, is a matter requiring rather delicate judgment. Selection of cold-wet climatic criteria, as used in this report, is based on: (1) studies conducted in the field and laboratory by physiologists and biophysicists of the Quartermaster Corps; (2) experience of other individuals living in the field and conducting tests under cold-wet conditions; (3) study of climatic conditions as they occur at typical cold-wet places on the earth, such as the Aleutian Islands; (4) examination and study of available literature, much of it based upon research by scientists of the Quartermaster Corps over a period of more than ten years; and (5) a study performed by the Weather Bureau for the Quartermaster Corps using data from selected stations in the United States and Alaska, resulting in the adoption of the criteria to be used in this report.

The four mutually exclusive combinations of cold-wet conditions selected for use in this report are as follows:

A. Observations with falling precipitation or fog at the time of observation, with temperatures from 23° F. through 59° F.

B. Observations with falling precipitation or fog at the time of observation, with temperatures from 60° F. through 67° F. and wind of 5 m. p. h. or more.

C. Observations with no falling precipitation or fog at time of observation, with snow on ground, and with temperatures from 23° F. through 49° F.

<sup>1</sup> This paper is published with the permission, but not necessarily the indorsement, of the Department of the Army. It is based upon *Technical Report EP-25*, Quartermaster Research and Development Center, Natick, Mass., July 1956.



FIGURE 1.—Location of the 61 stations used in the study.

D. Observations with no falling precipitation or fog at the time of observation, with no snow on ground, with 6–10 tenths clouds, and with temperatures from 23° F. through 49° F.

True cold-wet conditions cannot be defined by any one meteorological element, but rather result from two or more elements in combination. For example, snow on the ground cannot be considered as indicative of cold-wet conditions unless accompanied part of the time by air temperatures near or above freezing. The Arctic and Subarctic have snow on the ground much of the winter, but, since winter temperatures usually remain well below freezing in these regions, cold-dry rather than cold-wet conditions prevail, with quite different problems.

Certain weather elements directly associated with cold-wet conditions are not included in the criteria because they were not available on punched cards. Two of the more important of these missing elements are radiation and relative humidity. An attempt has been made to compensate for this deficiency by including falling precipitation and cloudiness in the criteria. High relative humidities and low radiation values are usually associated with these elements.

In considering the criteria presented above, it should be emphasized that they define cold-wet only in terms of *climate*; given criteria may or may not have application to specific physiological or biophysical problems involving the reaction of man to this climate. All the criteria have a bearing on some aspect of outdoor activities and needs for clothing and footwear protection.

### 3. DATA

Hourly data used in preparing this study were compiled by personnel of the U. S. Weather Bureau for 61 broadly representative stations (fig. 1) in the United States, in accordance with the above criteria provided by the Environmental Protection Research Division, Quartermaster Research and Development Command. Tabulation was performed at the National Weather Records Center, Asheville, N. C. using data available on punched cards. The period of record was limited to five years (July 1948

through June 1953) since observations for “state of ground,” required in determining the existence of a snow cover, were not available for the years prior to 1948.

The 5-year period of record used in this study includes approximately 43,000 hourly observations for each station, a sample large enough to provide a representative picture of the situation at the stations and a generalized picture for the country.

State of ground, reported every 6 hours at U. S. Weather Bureau stations, was used to determine the presence or absence of a snow cover. If a 6-hourly observation showed “snow-on-ground” in an amount greater than a trace, it was considered that the succeeding five hourly observations also had snow-on-ground. If no snow was on the ground at the time of the 6-hourly observation, the succeeding five hourly observations were considered to have no snow-on-ground, except that if falling snow was reported on two consecutive hourly observations, the second and remaining observations within the 6-hour period were also considered as having snow on the ground.

Data were used only from lowlands and scattered stations in interior plateaus. No attempt is made to analyze mountain conditions since they vary considerably with slight differences in location, and data from mountains are inadequate. Latitude, slope, altitude, exposure, and other factors strongly influence the climate in mountains, including the distribution and frequency of cold-wet conditions. In general, it may be expected that cold-wet conditions will occur earlier in fall and will last later in spring in mountains than in adjacent lowlands. At high altitudes in some of the mountains of the western part of the country these conditions may persist throughout the summer. During winter, at moderate to high altitudes, temperatures are usually below 23° F., and cold-dry rather than cold-wet conditions occur.

### 4. MONTHLY FREQUENCIES

The total frequency of occurrence (in percent) of all four criteria combined, for each of the 61 stations used, for each month of the year, is given in table 1, together with the average percent per month on an annual and October–April basis.

Figures 2 through 13 were designed to show the broad geographical and seasonal differences of cold-wet conditions in the United States. The point values of table 1 were plotted on monthly maps, and isarithms were interpolated at intervals of 10 percent frequency. The isarithms are not sharp lines of discontinuity between regions, but represent values in a gradual transition between greater and lesser frequencies. The result is a generalized picture of conditions in the lowland and plateau areas that constitute the greater part of the United States.

#### SEPTEMBER THROUGH APRIL

The greatest frequency and extent of cold-wet conditions in the United States occurs during the period from October through April. For purposes of discussion,

Table 1.—Percent frequency of occurrence of cold-wet conditions at stations in the United States. (Period of record 1948–1953.)

Station	Monthly percent												Average percent per month	
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Oct.-Apr.
Phoenix, Ariz.	18.5	10.5	7.4	2.7	0.5	0.0	0.0	0.0	0.1	1.0	4.1	13.7	4.9	8.3
Yuma, Ariz.	10.2	3.4	2.2	.6	.1	.0	.0	.0	.0	.6	1.7	7.3	2.2	2.2
Little Rock, Ark.	47.0	37.1	29.4	12.7	7.5	.5	.1	.1	3.5	10.0	23.8	40.7	17.7	28.7
Texarkana, Ark.	38.1	32.6	22.8	10.9	6.1	.7	.0	.1	2.3	7.2	21.0	35.9	14.8	24.1
Fresno, Calif.	49.5	31.7	23.7	7.1	2.2	.3	.0	.0	.6	3.9	24.5	59.6	16.9	28.6
Sacramento, Calif.	51.0	34.1	25.8	9.3	3.8	.9	.1	.1	.9	6.7	25.0	58.9	18.1	30.1
San Diego, Calif.	20.1	18.4	9.4	9.2	4.5	2.6	3.4	2.6	5.5	9.2	14.5	16.1	9.6	13.8
San Francisco, Calif.	41.5	34.0	24.3	14.9	8.5	7.1	6.0	7.8	5.9	11.5	20.5	37.8	18.3	26.4
Denver, Colo.	20.2	39.6	41.1	40.1	24.5	9.1	3.0	2.2	7.4	18.3	32.5	38.5	23.8	34.2
Washington, D. C.	56.7	51.2	43.4	27.2	15.2	4.7	.0	.7	7.0	15.2	38.1	55.1	26.2	41.0
Jacksonville, Fla.	15.9	17.6	9.5	3.9	.8	.1	.0	.0	.2	2.9	10.0	21.0	6.8	9.0
Miami, Fla.	1.0	3.3	.8	1.0	.1	.0	.0	.0	.0	.1	.8	1.6	.7	1.2
Atlanta, Ga.	38.9	35.3	31.7	14.1	4.2	.7	.2	1.4	4.7	12.9	28.4	50.2	18.6	30.2
Boise, Idaho	56.7	59.0	59.9	23.4	16.5	7.3	.2	.7	4.3	19.5	50.3	74.9	31.1	49.1
Pocatello, Idaho	50.3	51.7	59.8	27.3	25.0	8.3	.6	.9	6.4	24.8	53.2	64.3	31.0	47.3
Chicago, Ill.	59.0	61.5	59.6	47.3	16.6	4.4	2.2	3.8	7.5	20.7	54.3	51.5	32.4	50.6
Des Moines, Iowa	38.6	56.2	57.8	43.2	16.1	6.9	2.4	4.8	6.8	16.3	38.1	43.5	27.6	42.0
Goodland, Kans.	28.6	33.9	40.0	36.5	22.0	8.3	5.4	6.9	10.7	17.7	34.5	34.5	23.2	32.2
Wichita, Kans.	33.7	42.6	38.5	26.9	10.8	3.6	1.6	2.2	6.3	9.8	28.6	37.7	20.2	31.1
Louisville, Ky.	63.1	52.9	46.0	32.5	12.8	2.6	.5	1.5	6.6	18.8	42.2	54.6	27.8	44.3
New Orleans, La.	18.3	22.2	14.2	6.9	.8	.0	.0	.0	.0	2.8	13.9	24.3	8.6	14.7
Caribou, Maine	30.3	27.4	61.1	74.6	37.8	19.7	10.8	14.7	26.2	52.2	70.0	42.8	39.0	51.2
Portland, Maine	57.2	52.9	65.8	54.3	34.8	16.7	8.2	13.4	20.5	36.5	59.2	51.5	39.2	53.9
Boston, Mass.	64.0	65.6	61.9	45.8	29.1	7.7	4.8	5.6	9.4	21.3	46.6	51.9	34.5	51.0
Calumet, Mich.	26.9	31.4	49.8	69.8	39.4	21.2	11.5	12.4	26.3	52.9	70.3	40.7	37.7	48.8
Sault Ste. Marie, Mich.	38.7	38.2	58.9	57.6	35.7	22.6	14.5	18.4	32.5	57.1	77.6	54.1	42.2	54.6
Duluth, Minn.	17.3	26.5	49.6	67.2	39.0	20.5	15.9	14.1	28.6	48.1	56.1	30.7	34.5	42.2
Minneapolis, Minn.	25.9	44.9	58.3	50.0	18.6	7.6	3.4	6.0	12.6	26.8	50.8	36.1	28.4	41.8
Kansas City, Mo.	41.0	49.3	46.9	32.4	10.0	2.6	1.7	1.6	5.9	13.3	32.9	44.0	23.5	37.1
St. Louis, Mo.	53.7	52.5	46.0	33.5	9.6	2.3	.7	1.4	6.4	15.4	40.1	52.0	26.1	41.9
Billings, Mont.	37.9	56.8	45.5	39.3	24.9	14.4	4.1	3.4	17.3	31.5	50.0	50.1	31.3	44.4
Great Falls, Mont.	40.9	50.5	48.4	40.0	29.5	19.5	5.4	5.7	18.7	30.4	52.1	47.9	32.4	44.3
Grand Island, Nebr.	36.8	45.7	47.6	39.9	17.8	6.3	4.5	4.5	7.6	18.5	40.2	40.5	25.8	38.5
Elko, Nev.	47.4	46.2	56.0	32.0	24.1	7.5	1.5	.0	6.6	21.0	39.6	53.5	28.0	42.2
Las Vegas, Nev.	34.9	18.2	13.4	2.7	1.1	.4	.0	.0	.3	1.7	9.2	25.9	9.0	15.1
Reno, Nev.	47.0	39.9	44.0	21.0	16.4	4.6	.5	1.2	5.6	13.6	26.0	50.5	22.5	34.6
New York City, N. Y.	63.6	53.4	55.2	35.1	21.4	6.7	1.5	.9	5.1	12.6	37.8	54.0	28.9	44.5
Syracuse, N. Y.	65.4	65.3	65.5	53.8	24.4	6.5	3.3	6.3	18.2	39.5	67.3	64.2	40.0	60.1
Asheville, N. C.	50.1	43.1	39.6	25.3	13.3	5.8	3.4	8.3	20.9	29.7	38.1	49.2	27.2	39.3
Raleigh, N. C.	37.6	39.6	29.0	15.7	8.0	3.1	.6	1.1	5.1	14.8	25.5	42.7	18.6	29.3
Bismarck, N. Dak.	11.0	25.6	44.7	48.0	26.0	11.5	3.9	5.8	15.6	35.0	40.0	21.6	24.1	32.3
Fargo, N. Dak.	8.9	27.2	49.7	47.8	23.6	9.6	4.2	6.0	13.7	35.0	46.8	23.8	24.7	34.2
Cleveland, Ohio	68.1	64.3	65.3	51.2	17.4	4.6	2.3	3.7	9.2	27.1	60.9	61.9	36.3	57.0
Dayton, Ohio	69.9	62.7	58.2	45.2	16.7	5.6	1.0	4.1	9.9	26.1	55.4	58.8	34.5	53.8
Oklahoma City, Okla.	34.2	38.9	27.0	18.5	9.3	1.6	.7	.0	3.1	8.1	21.4	32.6	16.3	25.8
Medford, Oreg.	77.4	67.9	58.9	28.0	23.6	9.3	.7	.6	5.8	29.1	61.4	83.9	37.2	58.1
Portland, Oreg.	74.5	75.2	74.6	36.2	23.4	11.7	3.2	3.0	15.1	43.2	69.3	83.3	42.7	65.2
Harrisburg, Pa.	70.2	60.6	55.5	39.8	18.8	5.4	1.0	1.3	10.1	23.8	54.6	65.4	33.9	52.8
Charleston, S. C.	23.3	23.0	18.5	8.6	2.3	.2	.0	.1	2.4	9.1	14.6	33.6	11.3	18.7
Huron, S. Dak.	19.7	40.8	51.5	44.8	23.0	7.7	2.9	4.5	10.8	27.8	40.4	27.1	25.1	36.0
Rapid City, S. Dak.	30.3	40.0	45.0	42.7	27.2	10.4	4.6	4.3	12.3	27.0	39.7	33.7	26.4	36.9
Nashville, Tenn.	53.6	46.0	36.4	23.2	6.3	1.6	.1	.7	3.9	15.4	35.2	48.0	22.5	36.8
Amarillo, Tex.	27.7	30.0	25.4	18.6	11.4	3.4	2.3	3.4	6.5	7.9	20.8	28.6	15.5	22.7
Brownsville, Tex.	14.4	13.2	7.4	1.4	.6	.0	.0	.0	.0	1.6	5.5	10.8	4.6	7.8
El Paso, Tex.	22.5	14.9	8.4	5.3	1.0	.3	.7	.4	1.1	2.6	10.2	18.9	7.2	11.8
Houston, Tex.	27.9	29.1	12.7	8.3	3.3	.2	.0	.1	.1	6.3	19.0	25.6	11.0	18.4
Salt Lake City, Utah	51.3	47.7	54.2	23.3	16.5	3.9	.5	.7	3.4	17.1	45.0	71.4	27.9	44.3
Spokane, Wash.	55.5	69.1	65.2	34.1	20.2	13.1	2.7	2.3	8.8	39.0	70.3	70.3	37.6	57.6
Tatoosh, Wash.	81.8	80.3	66.1	40.9	32.3	32.3	32.3	34.7	33.7	39.8	66.5	82.1	55.9	71.0
Cheyenne, Wyo.	34.5	47.8	43.0	40.4	37.1	16.9	6.4	5.9	17.0	25.0	38.3	42.8	29.6	38.8
Sheridan, Wyo.	35.7	52.5	49.8	42.1	27.7	13.2	5.5	3.1	15.9	32.2	48.7	42.2	30.7	43.3

September is included in this period, for during this month the frequency and extent of cold-wet conditions first begin to increase throughout the country after the relatively infrequent occurrence during summer. The frequency of cold-wet conditions does not increase to a winter maximum in all parts of the country and then decrease in spring; the winter maximum occurs in some parts of the country, but in areas such as the North Central States midwinter is too cold to be wet.

In September (fig. 2) only the Appalachian area and the extreme northern part of the United States, especially the northwestern part of Washington, show frequencies of cold-wet conditions of 20 percent or greater. Most of the United States has less than 10 percent occurrence during this month.

During October (fig. 3) there is a considerable increase (over September) in cold-wet conditions in the northern part of the country, especially in New England and in the vicinity of the Great Lakes where increases of about 20 percent occur. During this month approximately the northern quarter of the country has cold-wet conditions at least 30 percent of the time. In the extreme northern part of the Great Lakes area (represented by Calumet and Sault Ste. Marie, Mich.) and in Caribou, Maine, these conditions occur over 50 percent of the time; secondary centers occur in the extreme Northwest (Tatoosh Island, Wash., and Portland, Oreg.) and in the Appalachian area as far south as North Carolina. The southern part of the country has cold-wet conditions less than 10 percent of the time, with Miami, Fla., recording less than 1 percent.

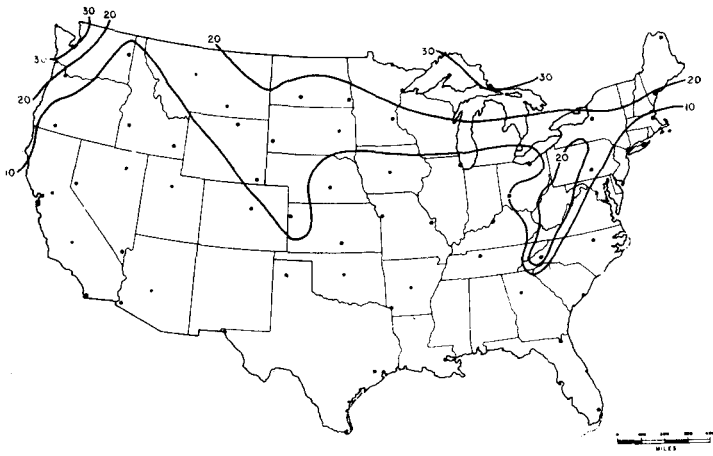


FIGURE 2.—Frequency (percent) of cold-wet conditions during September.

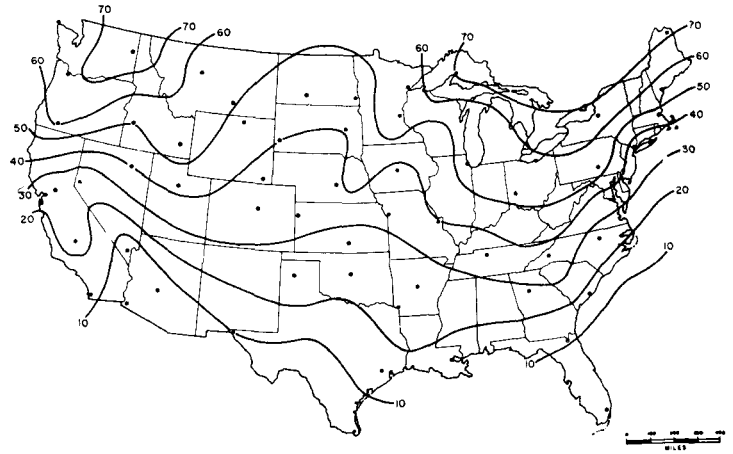


FIGURE 4.—Frequency (percent) of cold-wet conditions during November.

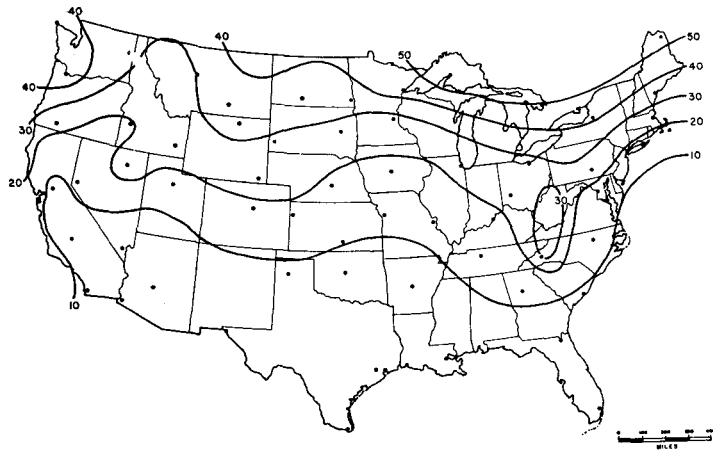


FIGURE 3.—Frequency (percent) of cold-wet conditions during October.

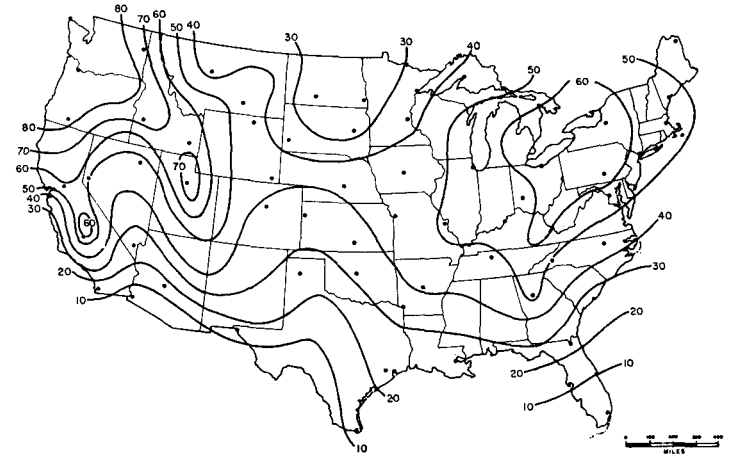


FIGURE 5.—Frequency (percent) of cold-wet conditions during December.

The sudden increase that occurs from September to October continues into the month of November (fig. 4). Northeastern United States, the Great Lakes areas, and the Pacific Northwest have cold-wet conditions from 50 to over 70 percent of the time. The southern part of the country shows increases of between 20 to 30 percent, and only the southern portions of Florida, Texas, and Arizona, and southeastern California have cold-wet less than 10 percent of the time.

Only a slight rise (10 to 15 percent) occurs in the north central part of the country, owing to the increase of very cold weather during this month.

In December (fig. 5), cold-wet frequencies actually decrease in the northern part of the country, except in the Pacific Northwest. The greatest increases occur in California and at the intermontane stations of the western United States where cold-wet conditions occur as far south as northern Arizona and New Mexico as much as 30 to 40 percent of the time.

In the north central part of the country the pronounced influence of very cold weather is now evident. Marked decreases in cold-wet frequency, of the order of 15 to 25

percent, occur in Minnesota, North and South Dakota, and parts of adjoining States. During January and February, these States are dominated by very cold, dry, polar continental air which has its source in interior, snow-covered Canada. Temperatures are usually much too low for cold-wet conditions to occur. The decrease also occurs in northern Maine, and to a lesser extent, near the Great Lakes. To the south, slight increases of about 5 to 10 percent are noted in Texas, Oklahoma, Kansas, Colorado, and Nebraska. In these States the frequency of cold-wet conditions is probably limited by weather that is either too warm, too dry, or too cold.

The increased frequency of cold-wet conditions is particularly noticeable in the far western part of the country—California, Oregon, and Washington—where the winter rains, accompanied by cloudiness and lower temperatures, now prevail. In central and northern California these conditions occur 60 to over 80 percent of the time in December. Of considerable interest is the fact that the frequency in central and northern California is comparable to that of the Great Lakes and New England. Southern Florida, with 2 percent at Miami, con-

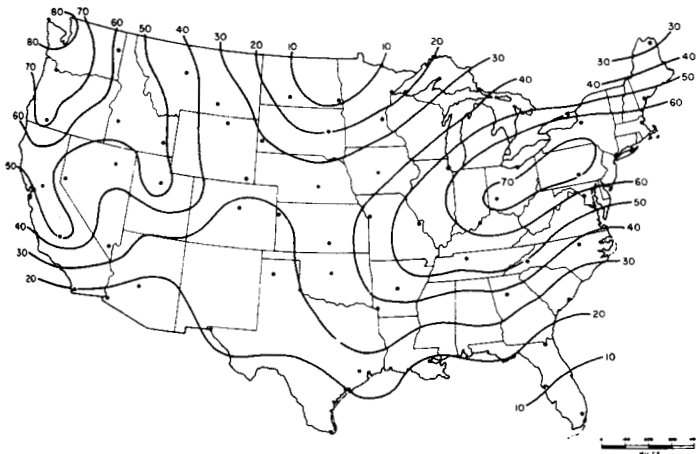


FIGURE 6.—Frequency (percent) of cold-wet conditions during January.

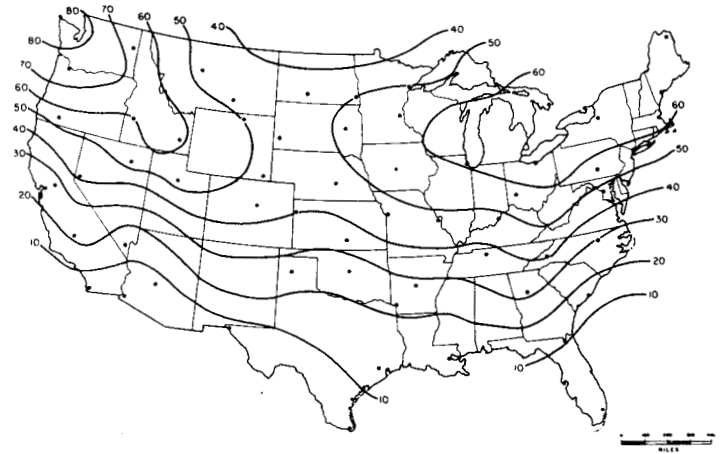


FIGURE 8.—Frequency (percent) of cold-wet conditions during March.

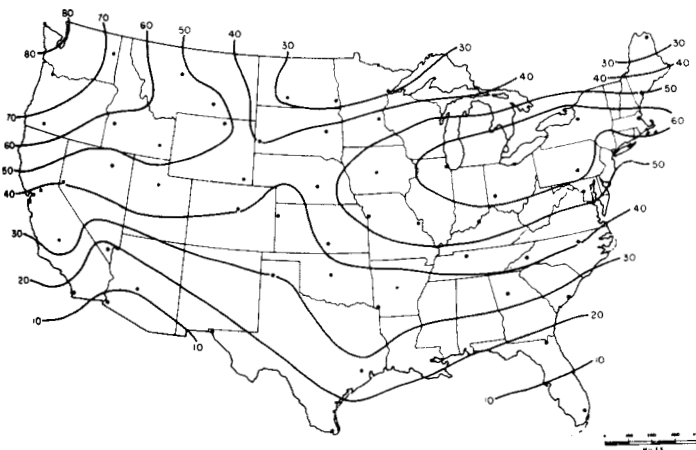


FIGURE 7.—Frequency (percent) of cold-wet conditions during February.

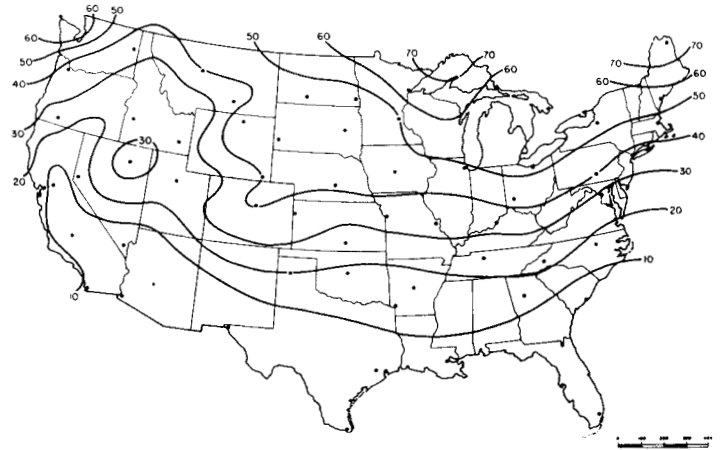


FIGURE 9.—Frequency (percent) of cold-wet conditions during April.

tinues to show the lowest frequency of cold-wet conditions.

In January (fig. 6) the decrease in frequency of cold-wet conditions in North and South Dakota continues with the frequency decreasing to between 10 and 30 percent. A decrease of 5 to 10 percent occurs in California, Oregon, and Maine, and an increase of about 10 percent is evidenced in Ohio and Pennsylvania, but with these exceptions conditions remain much the same as in December.

February (fig. 7) shows an increase in frequency in the North Central States, with slight decrease south of the Great Lakes, in Oregon, and in California. The increase noted in North and South Dakota is due to the rise in temperature following the coldest month of the year, January. In this month Miami has its greatest frequency, approximately 3 percent.

During March (fig. 8) the only significant changes in the frequency of cold-wet conditions are 10 to 20 percent increases in Minnesota, North Dakota, and South Dakota, and 15 to 30 percent increase in Maine. The extreme Pacific Northwest (Olympic Peninsula) continues to have the greatest frequency, 80 percent.

In April (fig. 9), with the retreat of the polar front and

cold airmasses, an increase of 15 to 25 percent is seen in the northern Great Lakes, North Central States, and northern Maine. Decreases of 20 to 30 percent are apparent in the southern part of the country, northern California, and the Pacific Northwest. During this month northwestern Washington relinquishes its lead (for the only time) to the northern Great Lakes and Maine which have 70 to 75 percent occurrence.

#### MAY THROUGH AUGUST

During this period cold-wet conditions occur less than 20 to 30 percent of the time throughout the country, with the following exceptions: (1) the Olympic Peninsula of Washington which has over 30 percent frequency all summer, and (2) all the northern States in May (fig. 10), with 25 to 40 percent occurrence. During June, July, and August (figs. 11 to 13), cold-wet conditions occur 10 percent of the time or more only in the far northern fringe of the country.

#### 5. COLD-WET REGIONS

From the preceding discussion and from examination

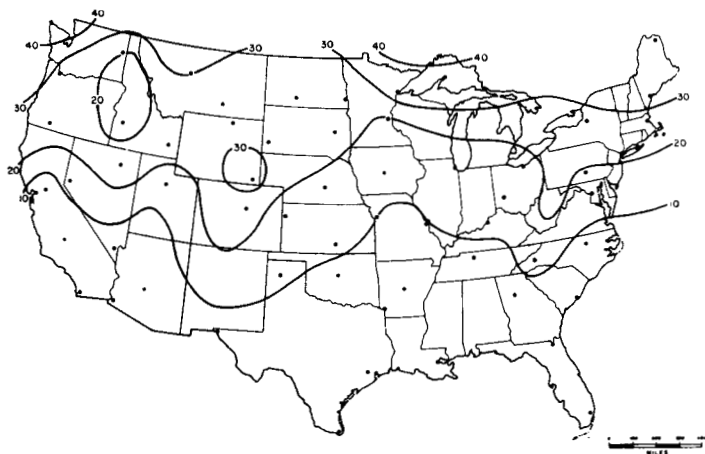


FIGURE 10.—Frequency (percent) of cold-wet conditions during May.



FIGURE 12.—Frequency (percent) of cold-wet conditions during July.

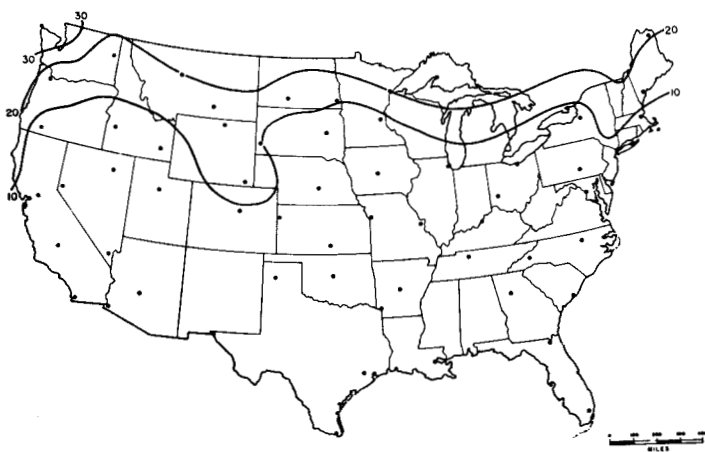


FIGURE 11.—Frequency (percent) of cold-wet conditions during June.

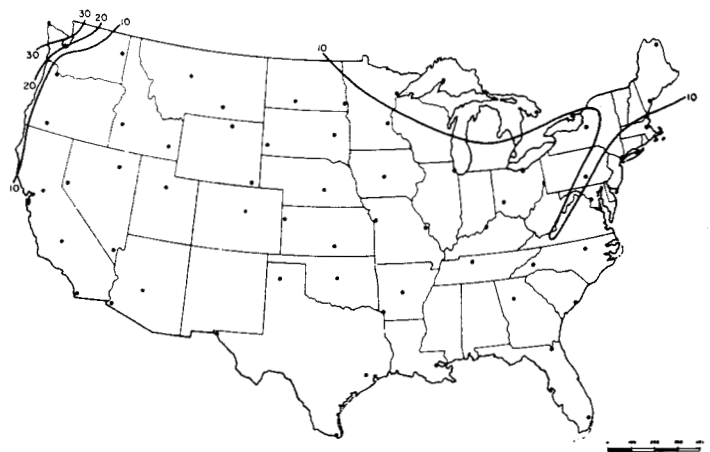


FIGURE 13.—Frequency (percent) of cold-wet conditions during August.

of the monthly maps, it is apparent that the greatest frequency of occurrence of cold-wet conditions is concentrated in two parts of the country: (1) the Pacific Northwest, and (2) the States bordering the Great Lakes, especially those east and south of the Lakes. These regions may be designated as the "cores" of cold-wet conditions; that is, they are the places where the greatest frequency exists, in terms of the defined criteria. Away from these two regions there is a gradual decrease in the frequency of cold-wet conditions.

The data for the year and for the cold season, presented in the last two columns of table 1 and plotted in figures 14 and 15, show the two major cold-wet cores on a generalized basis.

The average annual frequency of cold-wet conditions (fig. 14) shows that the northern two-thirds of the country has these conditions about 20 percent of the time or more. The Pacific Northwest shows a frequency of 40 to 50 percent, and the States bordering the Great Lakes, particularly Michigan, northern Ohio, northwestern Pennsylvania, and northern New York, have 35 to 40 percent.

A slight extension into extreme northern Vermont, New Hampshire, and Maine may also be observed.

## 6. COMPARISONS OF FREQUENCY OF OCCURRENCE OF EACH OF THE CRITERIA

Table 2 presents the frequency of occurrence of each of the four cold-wet climatic criteria at four selected stations during January, April, July, and October. Two of the stations, Duluth, Minn., and Tatoosh Island, Wash., are in the core regions previously discussed. Nashville, Tenn., and Boston, Mass., are representative of the transition to the areas of less frequent cold-wet conditions of eastern and southern United States.

Table 2 shows that with few exceptions Criteria A (cold and precipitation) and D (cold and cloudy) occur most frequently at each station, and Criterion B (mild, wet, and windy) is least frequent.

In January at Tatoosh Island, Boston, and Nashville, Criteria A and D occur more than 50 percent of the time (67.6 percent at Tatoosh), and Criterion C (cold with snow on ground) appears as a secondary maximum at Tatoosh (14.2 percent) and Boston (13.7 percent). The

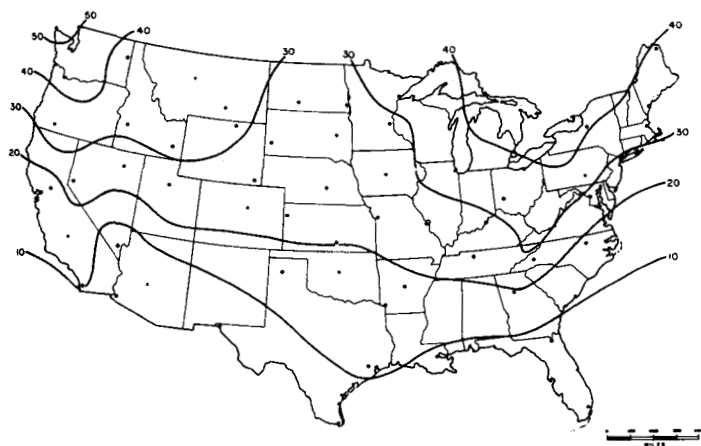


FIGURE 14.—Annual frequency (average percent per month) of cold-wet conditions. (Period of record, 1948–1953).

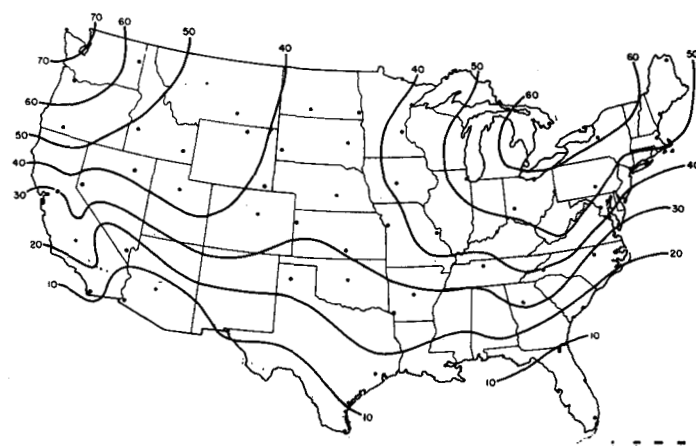


FIGURE 15.—Frequency (average percent per month) of cold-wet conditions during the period October through April. (Period of record, 1948–1953).

extensive occurrence of cold-wet climatic conditions during January is due to the low temperatures which occur throughout the country. The complete absence of Criterion B, (except at Nashville which shows 1.9 percent) is attributed to temperatures being at or below 60° F. at most places.

In April, the most noticeable changes are the increased occurrence of Criterion D at Tatoosh Island, the significant increase of cold-wet at Duluth (especially of Criterion C), and the decrease in all types of cold-wet conditions at Nashville. The large increase in Criterion D at Tatoosh Island indicates the continuation of winter cloudiness (18 days are cloudy) accompanied by a sharp decrease in frequency of precipitation from January to April. The increase at Duluth is due to warmer spring weather, with temperatures rising into the cold-wet range, and also to the persistence of a snow cover. At Nashville, temperatures are above the limit of the cold-wet range (67° F.) a greater proportion of the time, thereby reducing the frequency of occurrence.

In July, only Tatoosh Island and Duluth (32.2 and 15.9 percent, respectively) have significant percentage values of cold-wet conditions. The relatively low temperatures (mean daily minimum temperature during July is 51.5° F. at Tatoosh Island and 54.5° F. at Duluth) are accompanied by a summer maximum of precipitation frequency at Duluth, and by prevailing cloudiness (16

days of the month) at Tatoosh Island. Throughout most of the country, however, summer temperatures are too high, or precipitation and cloudiness too small, for cold-wet conditions to occur.

During October there is a considerable increase in cold-wet conditions at each of the four stations. Of greatest significance for this increase are the lower temperatures occurring throughout the country. Colder weather is accompanied by increases in cloudiness and precipitation at Tatoosh Island, and by increased cloudiness at Duluth.

## 7. CONCLUSIONS

The following generalizations are based upon data from a network of 61 representative lowland and plateau stations, and are not applicable to mountains:

a. The Pacific Northwest, especially the western part of the Olympic Peninsula in the State of Washington, has the greatest annual frequency of cold-wet conditions in the United States. In this region, such conditions occur 20 to 30 percent of the time in summer, and may be expected nearly 80 percent of the time from December through March.

b. There is a secondary center of cold-wet conditions in the northeastern part of the country, from the Great Lakes to New England. In this area, cold-wet conditions

TABLE 2.—Frequency (percent) of separate cold-wet criteria\* (for four sample stations)

Station	Criteria				Criteria				Criteria				Criteria			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
	January				April				July				October			
Tatoosh Island, Wash.....	38.6	0.0	14.2	29.0	22.8	0.0	0.0	43.2	32.1	0.1	0.0	0.0	28.5	0.0	0.0	11.3
Duluth, Minn.....	7.4	.0	9.7	.1	21.9	.0	34.4	10.9	10.2	5.2	.0	.5	18.3	.1	1.2	28.6
Boston, Mass.....	24.8	.0	13.7	25.6	21.5	.6	.6	23.2	.3	4.5	.0	.0	10.8	4.7	.0	5.8
Nashville, Tenn.....	27.3	1.9	1.0	23.4	10.4	1.8	.0	11.2	.0	0.1	.0	.0	10.7	2.3	.0	2.4

\*Criterion A—Observations with falling precipitation or fog at time of observation with temperatures from 23° F. through 59° F.

Criterion B—Observations with falling precipitation or fog at time of observation with temperatures from 60° F. through 67° F. and wind of 5 m. p. h. or more.

Criterion C—Observations with no falling precipitation or fog at time of observation with snow on ground and temperatures from 23° F. through 49° F.

Criterion D—Observations with no falling precipitation or fog at time of observation with no snow on ground, with 6–10 tenths clouds, and temperatures from 23° through 49° F.

persist from 40 to 70 percent of the time from October through April.

c. The period of greatest frequency of cold-wet conditions throughout the country is October through April, although in the northern tier of States from Montana to Michigan during winter, frequency drops because of prevalence of cold-dry conditions associated with temperatures below 23° F.

d. In winter (December through February) climatic conditions in North and South Dakota are similar to those usually found in the Arctic and Subarctic during early spring and late fall, with cold-wet conditions alternating with cold-dry.

e. Of the four criteria used, Criteria A and D occur most frequently, and Criterion B least frequently.

#### ACKNOWLEDGMENTS

The authors are indebted to personnel of the Office of

Climatology, U. S. Weather Bureau, and especially to Mr. Harold Crutcher, for technical advice and guidance given during the original planning for the tabulation of data used in this study, and for supervision of the data extraction. Cartography was by Mr. Roland Frodigh, Cartography Section, Environmental Protection Research Division, Quartermaster R and D Center.

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